Activities at CODE Analysis Center

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S. Schaer, R. Dach, M. Meindl,
H. Bock, C. Flohrer, A. Jäggi, S. Lutz, L. Ostini, L. Prange,
A. Steinbach, D. Thaller, P. Walser, G. Beutler

Astronomical Institute, University of Bern, Switzerland

Overview

Since mid-2003, CODE has been generating its products from a rigorous combination of GPS and GLONASS observations. In this way, best possible consistency of the orbit products is guaranteed. This may be considered as an essential step towards the analysis of multi navigation satellite constellations, specifically in view of the upcoming European Galileo system.

Highlights

Continuous parameterization, particularly for Earth orientation parameters (EOP) (see e.g. Fig. 2), troposphere zenith path delays (ZPD) and horizontal gradient parameters, as well as ionosphere parameters, allowing the connection of the parameters at day boundaries.

Completion of GNSS orbit products with respect to all transmitting GNSS satellites available without exception. Reliable accuracy code information is provided (see Fig. 6).

Generation of uninterrupted orbits for GPS satellites being repositioned. Corresponding events are identified with a maneuver flag in the SP3c orbit files. Orbit initialization procedure is implemented for easy inclusion of brand new GNSS satellites, even if they do not provide broadcast navigation messages.

Automatic verification of IGS05 fiducial sites for consistent datum definition.

Fully automated GNSS data processing with the latest development version of the Bernese Software, including BPE (Bernese Processing Engine). The processing system is embedded in a comprehensive system of Perl modules. This includes instant alerting in case of BPE processing and technical failures, general IGS data flow problems, GNSS satellites or tracking stations constellation changes (Fig. 7).

External GNSS orbit validation on the basis of SLR data.

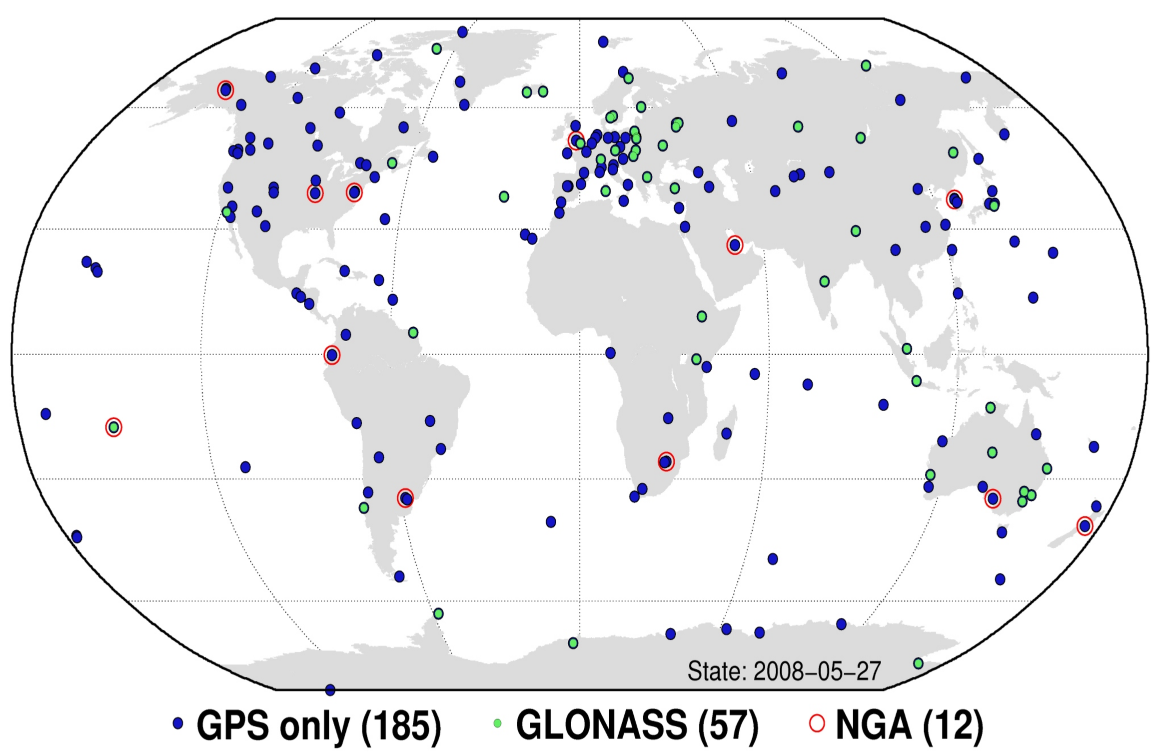

Fig. 1: IGS tracking network as considered in CODE's final GNSS analysis.

Most Important New Developments

A number of developments was made at the CODE analysis center of the IGS in the course of the last 2 years:

Week 1400

- Switch to the absolute GNSS PCV model IGS05.
- Consideration of receiver antenna radome codes (actually done since week 1367), relevant with the use of the absolute PCV model.
- Use of IGS05 TRF realization.

In addition, the following refinements were made:

- Improved CODE weekly analysis reports: verification of geodetic datum definition: residuals w.r.t. IGS05 are provided for the (extended) list of IGS05 fiducial stations in weekly analysis summary files; the 7 parameters of the corresponding Helmert transformation are listed; retrievals of weekly geocenter coordinates are given.
- SINEX: GNSS antenna offset parameters are included in SINEX for both the GPS and the GLONASS satellite constellation; CODE started to submit SINEX containing CoN coordinates; geocenter coordinates (constrained to 0/0/0) are included (e.g., for intersystem combination).
- Troposphere modeling: mapping function changed from Niell to GMF; a priori model for hydrostatic component: changed from a Saastamoinen-based to GPT model; gradient model refined. Note: Elevation mask angle of 3 degrees remains unchanged.
- Solar radiation pressure (RPR) a priori model: CODE'07 RPR model coefficients updated.
- Ocean tidal loading (OTL): CMC (center of mass) correction applied in GNSS POD process, based on the FES2004 OTL model; hardisp.f implemented to consider displacements from a total of 141 constituent tides.
- Mean pole computed according to IERS2003 standards.
- Phase windup: not only the geometrical part of the polarization effect is considered but the effect due to the nominal satellites' attitude motion is taken into account. Note: This model change does just affect the clock results.

Week 1439/1440

- A redesigned internal GNSS PCV file format is used.
- GLONASS ambiguity resolution is performed for shortest baselines (using the direct L1/L2 strategy). Baselines are formed following a refined strategy to increase the number of short and shortest baselines. Data preprocessing for shortest baselines is performed in a more suitable way.

Week 1477/1478

Computer platform change from SunOS 5.9 to Linux, x86_64. The new computer system is more powerful and allowed to implement the following extensions:

- Inclusion of all available (12) NGA stations in CODE's GNSS orbit, clock, and ionosphere analysis (see Fig. 1).
- Setup of GNSS satellite antenna PCV parameters specific to each individual satellite commenced (for later retrieval). Corresponding patterns are not only available for the ionosphere-free LC but also for the geometry-free (5-sec) L1-L2.
- Time resolution for EOP estimation increased internally (from 2 to 1 hr). The ERP results submitted to the IGS continue to be conform with a time resolution of 24 hours.
- Provision of phase-consistent high-rate (5-sec) GPS satellite clock values (see poster by Bock et al.).
- Generation of GNSS rapid SINEX files containing station coordinates and ERPs with a time resolution of 6 hours is foreseen as a contribution for the IERS inter-technique combination.

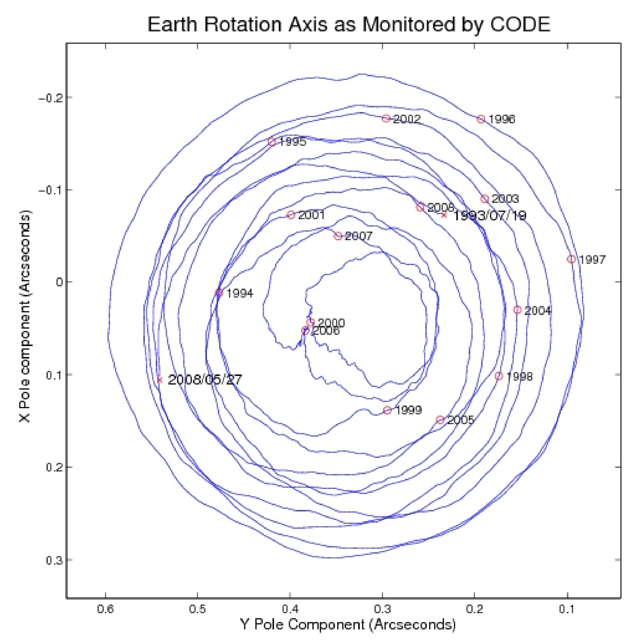

Fig. 2: Polar motion since 1993-07-19 as monitored by CODE.

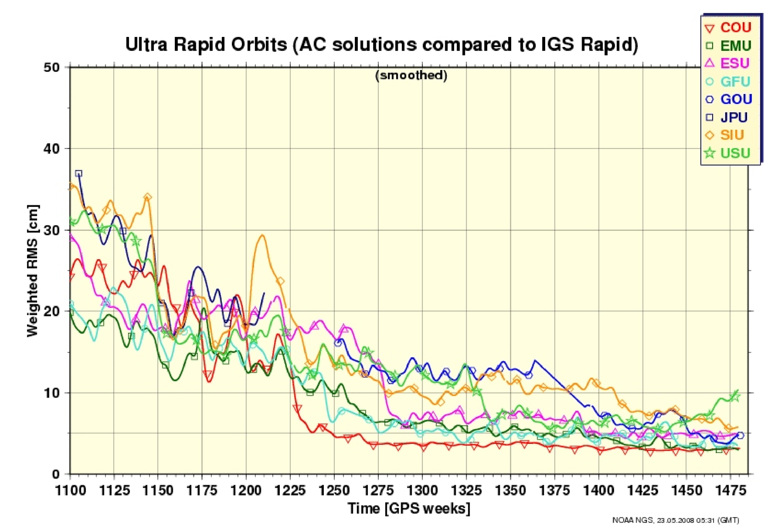

Fig. 3: Comparison from the ultra-rapid orbit combination, last 7 years. (Source: http://www.ngs.noaa.gov/igsacc/WWW/igsacc_ultra.html)

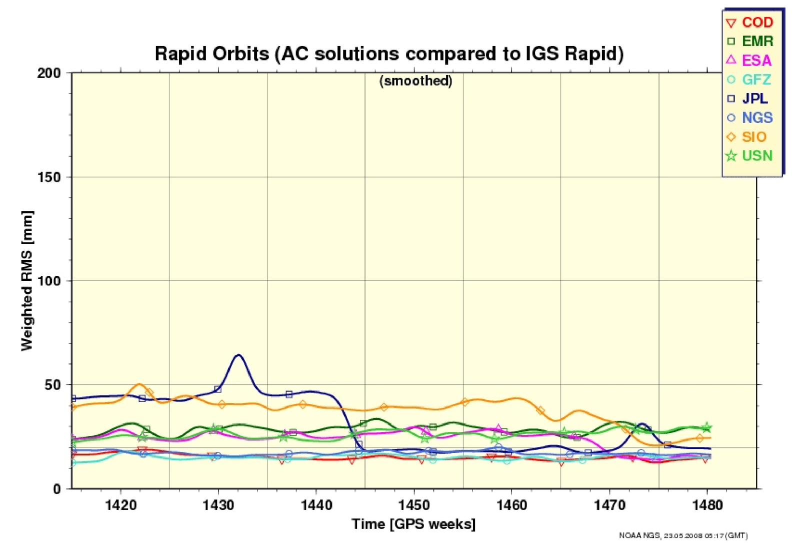

Fig. 4: Comparison from the rapid orbit combination, last 64 weeks. (Source: http://www.ngs.noaa.gov/igsacc/WWW/igsacc_rapid.html)

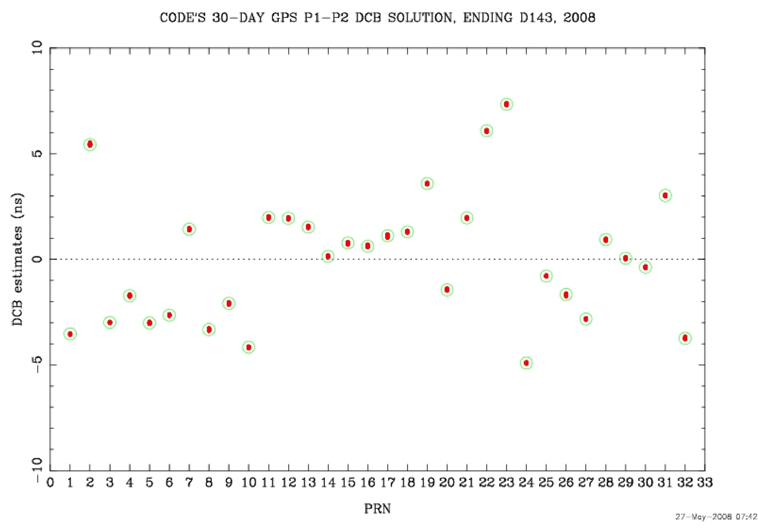

Fig. 5 (a): Group delay values P1-P2 for the GPS satellites.

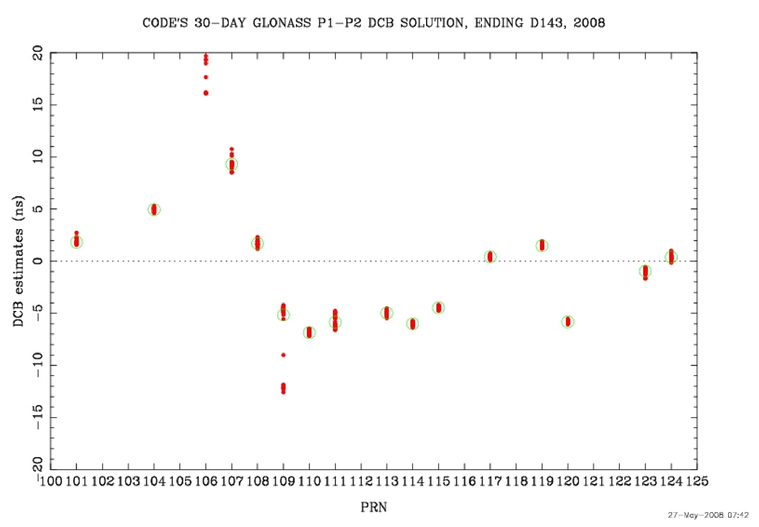

Fig. 5 (b): P1-P2 code bias estimates for the GLONASS satellites.

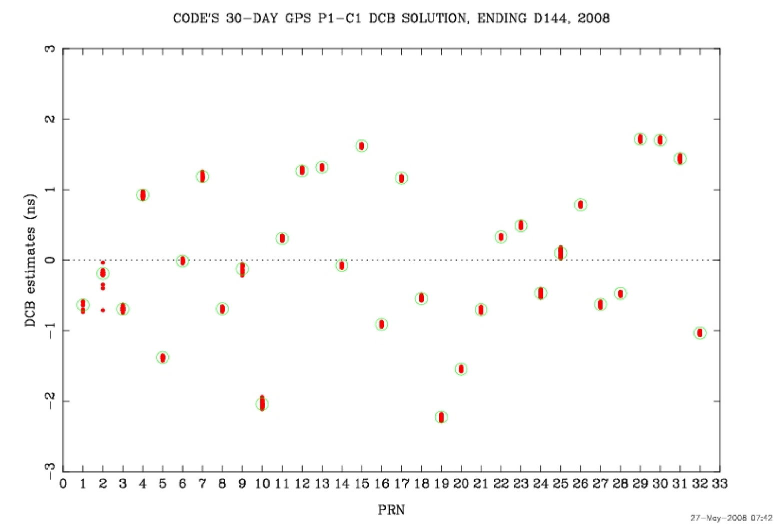

Fig. 5 (c): Group delay values P1-C1 for the GPS satellites.

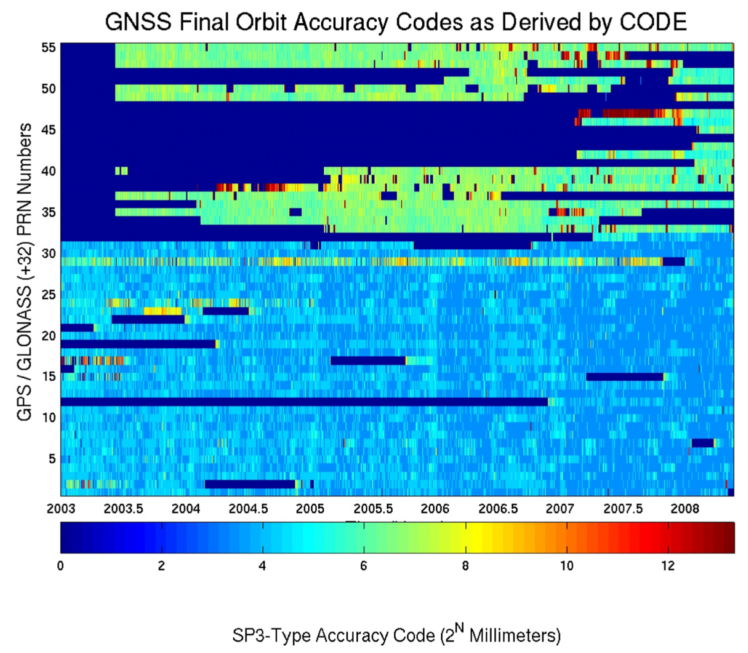

Fig. 6: SP3-type accuracy codes for final GPS and GLONASS orbits since 2003 as derived by CODE. Identifiable are e.g. decommissioned/inactive, eclipsing or "misbehaving" GNSS satellites, analysis model changes.

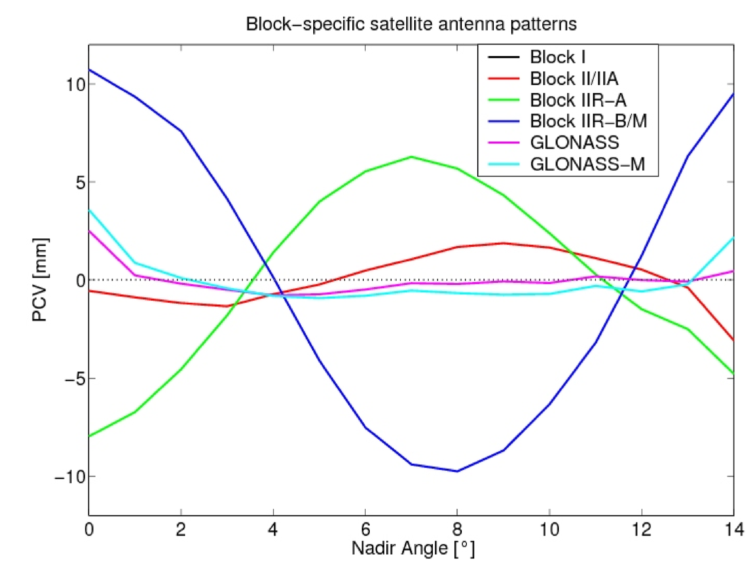

Fig. 8: Satellite antenna pattern for GPS and GLONASS (estimated from 10 months of data in 2005 and 2006). GLONASS patterns show a lower variation than the GPS PCVs.

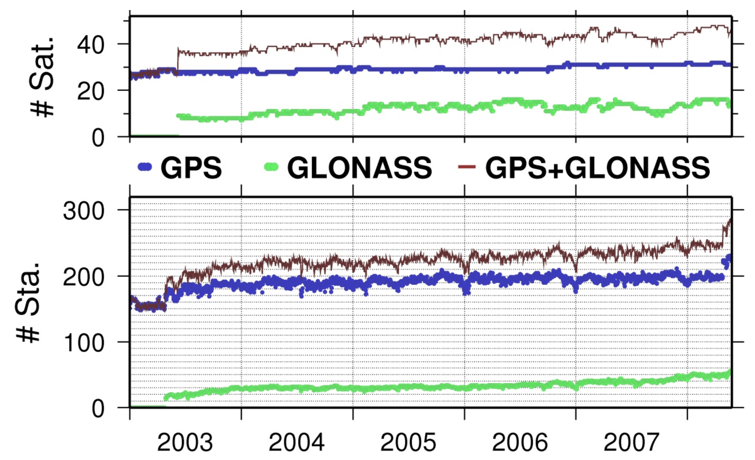

Fig. 7: Number of GNSS satellites and tracking stations since 2003 as considered in the CODE's analysis.

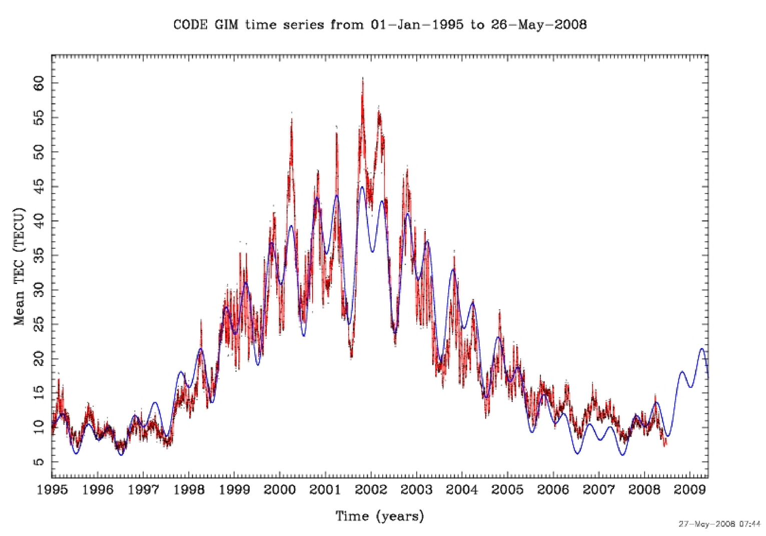

Fig. 9: Global mean TEC extracted from the GIMs produced by CODE covering more than one solar cycle.

GNSS Orbit Validation Using SLR

SLR observations allow for a fully independent validation of microwave orbits. Resulting range residuals provide useful information about the quality of GPS and GLONASS orbits derived from microwave observations and may help to detect systematic errors. Because of the high altitude of GNSS satellites the resulting residuals are primarily a quality indicator for the radial component of the validated orbits.

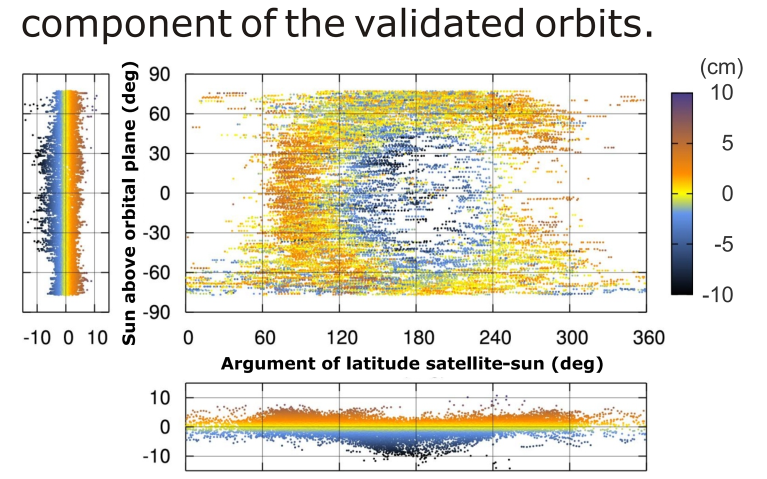

Fig. 10: SLR residuals w.r.t. the G05 and G06 orbits (ROCK RPR model). The bulge at around 180/0 disappears when applying the CODE'07 RPR model.

The CODE GNSS analysis products are accessible at:
http://www.aiub.unibe.ch/download/CODE/ or ftp://ftp.unibe.ch/aiub/CODE/

AIUB

Poster compiled by S. Lutz, May 2008
Astronomical Institute of the University of Bern
simon.lutz@aiub.unibe.ch